5 APPENDICES

5.1 APPENDIX 1 – RENEWABLE ENERGY TECHNOLOGIES

1. Renewable Energy Options

Small-scale renewable energy technologies (also referred to as microgeneration) offer the opportunity for low carbon distributed energy to reduce reliance on imported energy reducing energy consumption, costs and carbon emissions. Distributed energy, as defined by the government is "the local supply of electricity and heat which is generated on or near the site where it is used". There is the potential for small systems (typically up to a maximum generating capacity of 50kW) to play a significant role in tackling climate change alongside energy efficiency improvements and larger scale electricity and heat installations. These technologies have a particular role to play in areas of high landscape value where large installations are less appropriate. The appropriate package of technologies is very site specific depending on the building, site, occupancy rates, and natural resources available. Renewable energy technologies should always be installed in partnership with improved energy efficiency measures to maximise on both financial and carbon savings. General information about the different renewable energy technologies and their suitability to different sites is included below:

1.1 Electricity Generation

a. Wind Power

Wind turbines capture the winds energy with two or three propeller like blades, mounted on a rotor, to generate electricity. Systems can be on and off grid. There are two potential options for wind energy, which can provide small-scale on-site electricity generation; small ground mounted turbines and roof-mounted turbines.

When considering installing a small wind system you need to consider the following points to assess if the site is potentially appropriate for a wind system:

- *Wind Speed* – It is essential to have a good knowledge of wind speed at the proposed site. In the ideal world you would carry out wind speed monitoring for up to a year to get actual wind speed records for the site. However this is not always practical and can be costly. Therefore wind speed for a specific site can be estimated via the NOABL wind speed database. However estimated wind speeds taken from the NOABL database are based on 1km grid squares. Therefore they are merely an average of the wind speed in that local area. Local factors on the ground influence the site and dictate whether wind power is appropriate; most importantly do obstacles in the local vicinity such as trees and buildings create turbulence.
- *Location of the turbine* – Can the turbine be located so that the blades can capture the prevailing wind (Typically SW in the UK). If ground mounted what sort of height mast would the turbine need to be mounted on to raise it above surrounding potential turbulence, is there enough space for the turbine to be lowered when being serviced? If roof mounted is the building structurally sound to take the additional weight (in some cases a structural survey may be required which can be costly).

- *Planning* – Planning permission is required for all wind systems although there is some permitted development on small systems on domestic properties. Although planning permission for small wind systems is becoming increasingly easier to secure it is important to consider whether a wind turbine is appropriate in a particular location especially if located in high sensitivity areas such as National Parks and AONB's.
- *Where will the electricity be used*? – Will it be directly grid connected (if so are there any issues with this?) or will it feed directly into an end user e.g. house, school, office etc. In some cases permission from the DNO is required which may require a fee.

The cost of turbines varies considerably depending on output, manufacturer and location. Roof mounted turbines (1-1.5kW) typically cost in the region of £2,000 - £5,000. The smaller ground mounted turbines can cost around £12,000 going up to as much as £50,000-£60,000 for the turbines a t the larger end of the scale. Small changes in wind speed can influence potential output considerably, and in turn influence the economic viability of installing a wind system, hence the importance of wind speed on a site. Potential output of a turbine is very site and turbine specific so no generalisations can be made. When looking at installing a wind turbine you need to look at wind speed, location and cost together to select the right product for that specific location.

Most turbines have an estimated working life of between 20-25years and require annual servicing.

For more information on wind energy please visit the British Wind Energy Association website at www.bwea.org.uk

b. Solar Photovoltaics (PV)
This is the generation of electricity from the suns energy. Panels can either be bolted on to the south facing aspect or integrated into the roof as either panels or tiles. Alternatively panels can be mounted on to flat roofs (either ballasted systems or bolted on) or mounted on the ground. Systems can be both on and off grid connected.

When considering installing a solar PV system you need to consider the following points to assess if the site is potentially appropriate:

- *Suitable Location* – The optimum location for solar panels is on a south facing roof. Output decreases as you move from the optimum south facing position. Output decreases as you move away from optimum aspect and tilt (around 10% for SE and SW and 15-20% for East and West). Panels can be mounted on frames on flat roofs and can also be ground mounted.
- *Shading* - Panels are very susceptible to shading with output dropping to virtually zero across the whole array even if a small corner is shaded.
- *Is the roof structurally sound to take the weight of the system?* – In some cases you may need to get a structural engineer to carry out a survey

The Price of a solar PV system is very variable depending on size, panel type, method of integration etc. As a rule of thumb a cost of £5,000 per kWp for smaller systems can be used until detailed quotes are obtained. This price reduces, as the proposed system gets larger.

The systems come with a guarantee of around 20-25 years for product performance, although it is expected they will continue to generate long past this time. This guarantees that the system will still be generating at 80% capacity after this time. Installation has a separate guarantee. These guarantees will vary from manufacturer to manufacturer. Maintenance is minimal with the system being self-cleaning when installed at the optimum pitch of 45^{o}. If on shallower pitches it would benefit from cleaning every couple of years as dirt can build up. Once installed there are no operating or ongoing maintenance costs with few parts that can go wrong. The most likely part to need replacing is the inverter, which is guaranteed for 5 years but has an expected life of 10-15years. If this did need to be replaced you are looking at a current cost of around £200.

Typically it is recommended that all solar PV systems are grid connected unless the grid connection is very unreliable. Here batteries could be considered; however batteries are expensive relatively short-lived and need constant monitoring. Some systems can be installed without permissions from the distribution network operator (DNO). The maximum allowable size before permission is required is around 3kWp for single-phase sites and 9kWp for 3-phase supply sites. Your chosen supplier would help assist you with this.

Additional costs over and above the price above are planning fee, Cost of structural survey should you need to undertake one, cost of scaffolding plus miscellaneous connection costs. It is important to cost these out as early as possible to ensure you draw down grant for the full cost of the project. Discussion with your chosen installer will help you qualify these costs.

For further information on Solar PV visit the British Photovoltaic Association Website at www.pv-uk.org.uk

c. Hydro Power

Hydropower uses moving water to generate electricity. The energy of the flowing water turns a turbine, which is connected to an electricity generator. The level of power is dependent on the rate of flow of water (which is dependent on how far the water falls over a given distance, this is known as the head), the volume of water available and the efficiency of power conversion.

The basic micro hydro scheme has the following features:

- Good rainfall and catchment area
- Adequate flow or pressure (normally greater than 2 metres of head)
- A water intake above a weir or a damn and an outflow
- A water transport system
- A flow control system
- A turbine and generator

There are a few pieces of essential information that need to be obtained when a new site is being considered for hydro generation.

1. Firstly, you need to identify whether there is a significant energy resource. This involves estimating or measuring the flow and available head (vertical fall), and estimating what annual energy capture would result.
2. If the potential output of a scheme is attractive, then you need to be certain that permission will be granted to use all of the land required both to develop the scheme and to have the necessary access to it.
3. Finally, there needs to be a clear destination for the power: is there a nearby load that needs to be supplied, or is there a convenient point of connection into the local distribution network?

A good starting point when looking at any micro hydro installation is to talk with the Environment Agency. Their initial response may influence whether such a project is worth investigating further.

A pre planning application should be submitted. This would give detailed information about the scheme, most importantly exact location and where the water would be taken out and returned. This would then be circulated around all relevant departments to ensure all comments are co-ordinated. This will then influence whether the client decides to progress with a full planning application. For example if they insist on fish ladders the costs of these can generally make the economics of such a system unfeasible. A document outlining how the EA deal with applications and the process you should go through is available at www.environment-agency.gov.uk/subjects/waterres/564321/882330.

It is impossible to estimate costs for hydro installations as they are very variable and site specific dependent on the details of that location. In order to get an idea of cost you either need to carry out a feasibility study or do as much background research yourself prior to speaking with an installer.

For further information on Micro Hydro Power visit the British Hydropower Association website at www.british-hydro.org.

1.2. The sale of electricity Generated on site

With a grid connect system there are a number of ways of being paid for the electricity generated. However in all cases the most beneficial option is to use the electricity onsite. By using the electricity on site you are displacing electricity that you would otherwise purchase from your chosen supplier. If you pay 10p per kWh then you are saving this for every unit you generate yourself on site.

If there is a chance that not all electricity generated will be used on site you can install an export metre. This metre is NOT installed by the installer but by your chosen utility company. These are often installed for free but some companies will charge. Typical price at the moment is up to a maximum of £200. However the government is increasingly putting pressure on companies to offer better deals to small generators. Once your system has been commissioned you can shop around for the best package which looks not only at what the utility company will charge to install an export meter (if anything), what they will pay you for your exported electricity but also what they will charge for imported electricity assuming you need to have them as your supplier if they are to purchase any your exported electricity.

Whether you use the electricity on site or export it you are currently eligible for Renewable Obligation Certificates (ROC's) for every unit of electricity generated. When the system is installed and commissioned by your chosen installer they will fit a generation metre. This is OFGEM approved and the figure recorded on this will be used to calculate the number of ROC's you are eligible to claim for.

ROC's are a tradable commodity and are currently worth around 9p per kWh. This price fluctuates depending on how much renewable electricity is being produced. Most electricity supply companies will purchase any exported electricity should you decide to go down this route and will also buy your ROC's from you. In addition brokers now exist who trade in ROCs. It is worth shopping around once your system is commissioned to secure the best deal available at the time.

It is worth being aware that the government is committed to introducing Feed in Tariffs by the end of 2009. What is still unknown is who will be eligible to claim them and what their value will be. One option being put forward is that domestic and not for profit buildings will be eligible to claim. A figure quoted in the recommendations was 30p per unit. This immediately changes the economics of any such system. However once Feed in tariffs are introduced it is unlikely that any further grant funding will be available as this increased income will be expected to pump prime take up of systems. If you were eligible to claim Feed In tariffs you would claim either ROCs or Feed in Tariff not both.

1.3 Space Heating and Domestic Hot water (DHW)

a. Solar thermal (Water Heating)

Solar water heating harnesses the suns energy to directly heat water, which is pumped round the panels. This is then used to heat the water in a cylinder via a heat exchanger. The water becomes preheated in the tank therefore less energy is used to bring the water up to temperature. In the summer months it may generate close to 100% of your needs. It is thought to average out at about 50% of your hot water needs over the course of the year. As with solar PV output decreases as the panels move away from the optimum south facing position although it is not as susceptible to shading as solar PV. Solar thermal is most commonly used for DHW requirements and rarely stacks up economically for space heating other than in large buildings with a high heat demand all year round (e.g. residential home). This is simply because the demand for space heating is in the winter when output from the solar thermal system is at its minimum. DHW demand is all year round.

Solar systems typically have guarantees for 10 years and are expected to last in the order of 20-25 years. The system is mostly maintenance free although different systems may have some maintenance requirements e.g. replacing glycol every three years (depending on system). Moving parts such as the pump may need replacing after 10-15 years.

Therefore when considering installing a solar thermal system the main points to consider are:

- *Location* – Do you have a suitable site, ideally a south facing roof, flat roof etc
- *Does the site have a large and regular DHW demand*?
- *Is the roof able to take the weight of the system* – A structural engineer may need to carry out a survey is there are any doubts

Solar Thermal is more affordable than many of the other technologies and is popular on domestic properties as these have a large and regular DHW demand all year round. Typical costs for a solar water heating system of the scale required for domestic or small community buildings is around £2,500 - £4,000. Larger systems for example schools are often in the region of £10,000. However prices are very variable and you should always shop around.

For further information on solar water heating please visit the Solar trade Association website at www.greenenergy.org.uk/sta

b. Woodfuel

Woodfuel systems are not suitable for every property. Due to the nature of woodfuel; boilers tend to be larger than those for gas or oil. There is additional capital cost compared to gas or oil equivalents, they require more space and need to be located in a position that is easily accessible to fuel delivery vehicles. However in the right locations they offer not only reductions in CO^2 emissions but reduced energy prices.

The use of woodfuel (this could be a chip, log or pellet boiler) is carbon neutral as for every tonne of CO_2 released into the atmosphere the equivalent is absorbed by growing trees (assuming the timber has been sourced from sustainably managed woodlands of which the majority in the UK is). Combustion of woodfuel is the easiest way to release energy, which in turns provides heating and DHW. Modern woodfuel boilers are fully automated and controlled by thermostats thus being similar when installed to a typical gas or oil heating system. Fuel is supplied via hoppers (which must be kept filled up in a similar way to filling your oil tank). These can be integrated into the boiler but require manual filling at regular intervals as they are smaller or are a separate fuel store. These tend to be larger, require less regular filling and feed the boiler automatically. However these bulk stores require quite a lot of space. Fuel is automatically fed to the boiler from these hoppers via an auger as hot water demands are placed on the system. This then feeds into your distribution system i.e. radiators. In sites with more erratic space heating and DHW requirements accumulator tanks are fitted to ensure the system can respond instantly to meet the demand.

Modern woodfuel boilers are so efficient (typically 90% plus) that there is virtually no smoke produced. The bulk of what comes out of the flue is carbon dioxide and water. Planning permission is sometimes required for locating the flue (depending on the size and required height of the flue) and in smoke free zones you need to ensure your preferred product is registered and eligible to be installed in these areas.

However there are some distinct differences between traditional woodfuel systems and equivalent fossil fuel systems, which require practical consideration at an early stage.

1. Woodfuel is a solid fuel. Issues of delivery, reception and storage need to be considered at a very early stage.
2. Modern woodfuel heating systems are efficient and reliable. However there are some key differences, which mean a woodfuel system, cannot simply be substituted for a gas boiler. Your heating engineer needs to understand and plan for these.
3. You need to ensure that whoever is in charge of managing the systems once commissioned is trained by the installer to ensure effective maintenance, servicing and fuel supply.

Small systems up to around 50kW are likely to opt for either a log or pellet system. Over this size woodchip generally offers the most economic option. However with all systems this is dependent on the availability of the right fuel at the right price in your local area. Price is very variable depending on the level of automation of the boiler; style of fuel store and whether the system is new build or retrofit, whether it is supplying a single or multiple buildings. However ball park figures for a small domestic system up to around 20kW is up to around £10,000 - £15,000. Larger systems are in the region of £50,000 for a small chip system up to around £200,000-£300,000 for larger systems e.g. 200kW plus. With woodfuel many of the costs are fixed irrelevant of whether you are installing a 50kw or a 500kW boiler.

For further information on woodfuel heating please visit the Renewable Energy Association website at www.r-p-a.org.uk. In addition the Biomass Energy Centre hosted and run by the Forestry commission is a good source of information (www.biomassenergycentre.org.uk)

c. Heat Pumps

Heat pumps utilise thermal energy taking low temperature heat from its surrounding. This could be the ground, surrounding air or a local water resource. This low-grade heat is then upgraded to a higher, more useful temperature. There are three main types of heat pump systems that could be considered, air source (ASHP), ground source (GSHP) and water source (WSHP). The systems consist of a heat exchanger, heat pump, and a heat distribution system. With ASHP you need to locate a unit at a site adjacent to the building with enough space for adequate airflow around the unit, for GSHP you need to install pipes either horizontally in the ground or as boreholes. WSHP take heat from water sources as either closed loop systems (operating in the same way as GSHP system) or open loop where the water is actually extracted and circulated around the system.

The captured low-grade heat is transferred to a heat pump, where it is used to heat up a refrigerant. The 'warmed' refrigerant is compressed increasing its temperature. The higher temperature refrigerant in turn heats the water to a higher temperature. The temperature raised for space heating is typically 45ºC - 50ºC and up to 55ºC for hot water as compared with 80^{o}c plus for traditional heating systems.

They are classed as a low carbon technology as electricity is still used to run the pump but for every unit used you get between 3 and 4 units of heat. The efficiency of heat pumps lies in the fact that they use low temperature heat created from renewable energy sources. Heat pump systems usually produce between two and four times as much heat from the same amount of fossil fuel depending on the system by using it to enhance the renewable energy of the land. For example for every 1 kW of energy used to run the pump 3kW's of heat are produced. GSHP offer better efficiencies, as the temperature of the ground is more stable than the air surrounding an ASHP.

Heat Pumps can be used to provide space and water heating and if required space cooling to a wide range of building types and sizes. Ideally Heat pumps are linked to distribution systems designed to operate at lower temperatures such as under floor heating specially designed radiators or hot air systems; it is only with these type of distribution systems that the efficiencies offered by these systems are realised. The most efficient distribution system is under floor heating or specially designed radiators. They are less efficient if used via a traditional wet radiator system, as the surface area available to deliver the heat is unlikely to be high enough as traditional systems work at higher temperatures. On average you would need an increase in surface area of around 1/3 for traditional radiators to be able to meet space heating requirements and the system would not run at optimum efficiency.

The financial and carbon savings offered my heat pump systems are only realised if they are installed in appropriate locations and are managed properly. This means maximising on off peak electricity tariffs and by running the system for longer lengths of time providing background heat; they struggle to bring rooms up to temperature quickly. For example if the heating has been off all night they cannot provide quick responses if the room thermostat is turned up. This means you manage the system by keeping the building at a certain temperature at all times and then setting the timer to increase temperatures in advance of requirements if for example you have a user group who will be sitting around for a long length of time and require higher temperatures. It is therefore ideal for new build projects where the efficiency of the building is high and able to retain heat for longer lengths of time or refurbishment is bringing a building up to high levels of efficiency in keeping with building regulations. You should not consider putting a heat pump system in a poorly insulated building as you will never realise the financial and carbon savings offered by such systems as the heat will literally just 'go through the roof'!

There are pros and cons to all types of systems and the heat pumps system opted for will be very dependent on the site. Do you have space for pipes for GSHP, is there a water source etc. Air source heat pumps are cheaper to install however they do not offer as good efficiencies as water and ground source heat pumps therefore savings longer term are not as good. In addition you may need planning permission to install the units.

Costs for heat pump systems are very variable as for woodfuel with costs being site specific. A GSHP for a small domestic or community building will cost in the region of £6,000-£12,000 and for an ASHP of similar size £6,000-£8,000. Larger GSHP system cost in the region of £50,000 for a 100kW system although again this is very site specific. ASHP have been predominantly designed for the domestic market so there are less large-scale systems available.

For further information on Heat Pumps visit the **'**The UK Heat Pump Network' website at www.heatpumpnet.org.uk and 'The Heat Pump Association' site at www.heatpumps.org.uk

5.2 APPENDIX 2 – CASE STUDIES